SPECIFICATION

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PHOSPHOR EMBEDDED DIE EPOXY AND LEAD FRAME MODIFICATIONS

Background of Invention

[0001] The present invention relates to an ultraviolet ("UV")/blue light excitable, visible light emitting phosphor. It finds particular application in conjunction with light emitting devices comprising a UV/blue light emitting die used in conjunction with the UV/blue excitable, visible light emitting phosphor and will be described with particular reference thereto. It will be appreciated, however, that the invention is also amenable to other like applications.

[0002] The advent of UV and blue LEDs of GaN-based epitaxial structures allowed, for the first time, generating white light from an LED. Luminescent phosphor materials have, heretofore, been applied on top of the LED. The phosphor material partially transforms the UV/blue light into longer wavelength visible light.

[0003] As used herein, the term "UV/blue LED" means an LED emitting in the UV range, or in the blue range, or in both the UV and blue ranges of the electromagnetic spectrum.

[0004] Successful implementation of such a device is of course dependent upon the efficient conversion of UV/blue light into visible light of the desired wavelength and the subsequent efficient extraction of the generated visible light from the device.

[0005] However, the medium of the UV die in such devices is relatively lossy and, therefore, the phosphors only partially absorb the light from the LED. The unabsorbed light is partially reflected by the phosphor particles back in the direction of the LED, and partially transmitted through the phosphor layer, in both cases reducing the total possible visible light output.

[0006] In addition, visible light emitted by the phosphor may never leave the device, due to internal reflection and/or absorption at various locations within the device structure.

[0007] The present invention provides a new and improved apparatus and method which overcomes the above-referenced problems and others.

Summary of Invention

[0008] A light emitting device includes a nitride compound, for providing at least one of blue and ultraviolet emission. An epoxy, embedded with a phosphor, is mounted to the nitride compound. A frame includes a surface having an uneven portion contacting the epoxy.

[0009] In accordance with one aspect of the invention, the nitride compound includes one of binary compound materials, ternary compound materials, and quaternary compound materials.

[0010] In accordance with a more limited aspect of the invention, the nitride compound is one of a group II through group VI-nitride compound.

[0011] In accordance with an even more limited aspect of the invention, the nitride compound is a group III-nitride including GaN.

[0012] In accordance with another aspect of the invention, the nitride compound and the epoxy are mounted to a substrate.

[0013] In accordance with a more limited aspect of the invention, the substrate includes sapphire.

[0014] In accordance with another aspect of the invention, the uneven portion is a designed surface.

[0015] In accordance with another aspect of the invention, the phosphor converts the at least one of the blue and the ultraviolet emission from the nitride compound to a visible light, which is emitted from the frame.

[0016] In accordance with another aspect of the invention, the frame further includes a smooth portion. Substantially none of the phosphor embedded epoxy contacts the smooth portion.

[0017] One advantage of the present invention is that it converts relatively more UV/blue light to visible light.

[0018] Another advantage of the present invention is that it efficiently converts UV/blue light, which is emitted toward the bottom of an LED die, to visible light.

[0019] Another advantage of the present invention is that the surface area of the lead frame, which contacts the phosphor, is created to increase the conversion of UV/blue light to visible light and concurrently decrease die epoxy degradation, which in turn increases system reliability.

[0020] Still further advantages of the present invention will become apparent to those of ordinary skill in the art upon reading and understanding the following detailed description of the preferred embodiments.

Brief Description of Drawings

[0021] The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawing is only for purposes of illustrating a preferred embodiment and is not to be construed as limiting the invention.

[0022] FIGURE *1* illustrates a solid state light emitting device secured to a frame according to the present invention.

Detailed Description

[0023] With reference to FIGURE *1* , a solid state light emitting device *10* includes a semiconductor die *12* and a frame *14* .

[0024] The die *12* includes a substrate *16* (e.g., sapphire) and a nitride compound *20* mounted on a first end *16a* of the substrate *16* . Although a group III-nitride compound is preferred, it is to be understood that other compounds (e.g., group II-nitride compounds and/or group IV through group VI-nitride compounds are also contemplated). The compound *20* provides at least one of blue and ultraviolet emission (e.g., less than about 500 nanometers). An epoxy *22* , which is embedded with a phosphor, is mounted on a second end *16b* of the substrate *16* . The phosphor embedded epoxy *22* contacts the frame *14* . Optionally, epoxy, which may or may not be embedded with the phosphor, covers additional portions of the substrate *16* .

[0025] The frame *14* includes two (2) portions *14a, 14b* . The first portion *14a* includes a smooth surface; the second portion *14b* includes an uneven surface. The uneven surface *14b* is designed to include, for example, ridges, grooves, dimples, and/or other shapes for creating a surface so as to direct UV light away from the die *12* . The uneven designed surface increases the surface area of the second portion *14b* of the frame *14* . The phosphor embedded epoxy *22* contacts the designed surface *14b* of the frame *14* .

[0026] The group III-nitride compound *20* of the preferred embodiment includes binary compound materials of, for example, GaN, InN, and AlN, ternary compound materials of, for example, InxGa1-xN, AlyGa1-yN, InzAl1-zN and/or quaternary compound materials of, for example, InuAlvGa1-u-vN, where u, v, x, y, and z are fractional numbers between zero (0) and one (1) exclusive and u + v is a fractional number between zero (0) and one (1) exclusive. Such group III-nitride compounds *20* are preferred as providing blue or ultraviolet emission (i.e., wavelengths below about 500 nm), having good reliability, and benefiting from a relatively mature processing technology. In the preferred embodiment, the group III-nitride compound *20* includes GaN. However, other materials are also contemplated.

[0027] The phosphor embedded in the epoxy *22*, which is between the substrate *16* and the second portion *14b* of the frame *14*, converts the emission from the group III-nitride compound *20* from a first range of wavelengths to a second range of wavelengths. More specifically, the phosphor converts blue/ultraviolet emission, which is within a first range of wavelengths greater than about 10 nanometers and less than about 500 nanometers, to a visible light, which is within a second range of wavelengths greater than about 400 nanometers and less than about 800 nanometers. The visible light is emitted from the designed portion *14b* of the frame *14*.

[0028] The light emitting device *10* of the present invention causes the blue/ultraviolet light, which is emitted toward the bottom of the die *12*, to be efficiently transmitted through the phosphor material *22*. Consequently, a greater proportion of the blue/ultraviolet light is converted to visible light over previous designs.

[0029] Electrode pads (electrical contacts) (not shown) on, for example, the group III-nitride compound *20* provide means for powering the semiconductor die *12*.

[0030] The preferred embodiment has been described in terms of converting blue/ultraviolet light to visible light. However, it is to be understood that other embodiments, in which light is converted from one wavelength to another wavelength from a semiconductor die, are also contemplated.

[0031] The solid state light emitting device *10* is manufactured by mounting the phosphor embedded epoxy *22* to the second end *16b* of the substrate *16*. The first end *16a* of the substrate *16a* includes a group III-nitride, which provides at least one of blue and ultraviolet

emission.

[0032] The designed surface *14b* is created on the frame *14* . Then, the second end of the semiconductor die *12* is mounted to the designed surface *14b* via the phosphor embedded epoxy *22* . Electrode pads (not shown) are connected to the semiconductor die *12* .

[0033] The invention has been described with reference to the preferred embodiment. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.